Salmonid Migration in Tributaries of Port Moody Arm, Burrard Inlet, BC

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SALMONID MIGRATION IN TRIBUTARIES OF PORT MOODY ARM, BURRARD INLET, BC

by

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PREFACE

This report summarizes the results of surveys of adult and juvenile salmon undertaken in 1998 and 1999 in the main tributary streams that enter Port Moody Arm, Burrard Inlet, BC.

The studies complement others that also were initiated in response to potential increases in the thermal discharge from British Columbia Hydro and Power Authority's (BC Hydro) Burrard Generating Station, into the marine waters of Port Moody Arm. This gas-fired steam electric generating station operates under a permit from the provincial government, and utilizes a once-through seawater cooling system. The permit allows for the discharge of up to 1.7 million m^3 daily of cooling water (≤ 27 °C), drawn from, and discharged to, Port Moody Arm.

An environmental impact study to assess any effects due to the thermal discharge was a requirement of an amendment to the provincial permit. A study plan was submitted by BC Hydro to federal and provincial regulatory authorities in 1996, and it was approved in 1997.

Studies were undertaken over the following 3 years and they investigated the effects of the thermal effluent on the growth of juvenile chum salmon, the heat budget of Port Moody Arm, the potential effects of the effluent on salmon behavior and survival, and on planktonic organisms. Other reports document the results of these investigations.

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ABSTRACT

Greenbank, J.D., S.L. Rendek, and I.K. Birtwell. 2001. Salmonid migration in tributaries of Port Moody Arm, Burrard Inlet, BC. Can. Manuscr. Rep. Fish. Aquat. Sci. 2557: 47 p.

Port Moody Arm, is situated at the eastern end of Burrard Inlet, BC. The arm is 6.5 km long with a mean width of 0.9 km and a mean depth at low tide of 8.8 m. The arm receives heat due to solar input and also the daily discharge of up to 1.7 million m^3 of cooling water at a temperature of ≤ 27 °C from BC Hydro's Burrard Generating Station (BGS) which is situated on its north shore. Chum salmon (*Oncorhynchus keta*) is the most prevalent species of Pacific salmon in the arm, and there was concern for their health, and that of other organisms because of these inputs of heat. This sudy was carried out to gather quantitative data on species, numbers, and timing of juvenile and adult migrating salmonids in Port Moody Arm. Surveys of the number of adult salmon migrating through the arm were conducted in the fall of 1998 and 1999. The trapping of downstream migrating juvenile salmon was carried out in Mossom Creek in the spring of 1999 and 2000.

The main tributaries to Port Moody Arm (Mossom, Noons, Sutterbrook as well as Schoolhouse North and South Creeks) were surveyed over the 1998 and 1999 fall spawning season. Chum salmon (*O. keta*) was the dominant species in all of the systems; coho salmon (*Oncorhynchus kisutch*) and chinook salmon (*Oncorhynchus tshawytscha*) were also observed. Total escapement estimates of chum salmon for Mossom Creek were 1803 in 1998 and 658 in 1999; low numbers of chum salmon were also recorded in the other systems that were monitored. Relatively low numbers of adult coho salmon were observed in Mossom, Noons, Schoolhouse North and Sutterbrook Creeks.

Adult chum salmon were first noted in Mossom Creek on October 5 and 6 in 1998 and 1999 respectively. The last fish was observed in early December in both years. The peak migration period extended from October 16 through November 9. It was estimated that the majority of the chum salmon moved through Port Moody Arm in the latter half of September and into October.

Water temperature data collected during September and October 1998 at 5-m depth in Port Moody Arm were used to determine if the temperature regime in the arm was suitable for adult salmon. The maximum temperature in September was 16.6 °C and was 13.0 °C in October. The preferred migration water temperature range for adult chum salmon in fresh water has been stated to be between 8.3 °C and 15.6 °C although no information is available for salt water. Therefore, it was concluded that the BGS cooling water effluent would not have an adverse effect on the migrating salmon.

A trap was deployed in Mossom Creek in spring 1999 and 2000 to enumerate the numbers of downstream migrating juvenile salmon. A total of 13,252 and > 18,000 chum salmon were captured and released in 1999 and 2000 respectively. The downstream migration period started in early March and was almost complete by the first week of May in both years. A total of 331 coho salmon fry were captured in 1999 and 875 in 2000. The majority of these fish were captured in March and April. Low numbers of coho smolts, cutthroat trout parr (*Oncorhynchus*

clarki clarki) and sculpin species were also captured in the trap. It was concluded the juvenile chum salmon are likely present in Port Moody Arm from March to July.

RÉSUMÉ

Greenbank, J.D., S.L. Rendek, and I.K. Birtwell. 2001. Salmonid migration in tributaries of Port Moody Arm, Burrard Inlet, BC. Can. Manuscr. Rep. Fish. Aquat. Sci. 2557: 47 p.

Le bras Port Moody, situé à l'extrémité est de l'inlet Burrard, fait 6.5 km de long et a une largeur moyenne de 0.9 km et une profondeur moyenne à marée basse de 8.8 m. Le bras est réchauffé par le rayonnement solaire et par la décharge quotidienne des eaux de refroidissement de la centrale thermique Burrard de BC Hydro, située sur sa rive nord, soit jusqu'à 1.7 million m^3 d'eau par jour à une température ≤ 27 °C. Cet apport de calories dans le bras inquiète certaines personnes qui pensent qu'il peut mettre en danger plusieurs organismes marins dont le saumon kéta (*Oncorhynchus keta*), l'espèce la plus abondante parmi les saumons du Pacifique qui fréquentent le bras. La présente étude a été réalisée pour rassembler des données sur les salmonidés, en particulier les espèces présentes, leurs effectifs et le calendrier de la migration des poissons immatures et adultes dans le bras Port Moody. Les relevés concernant les saumons adultes ont été effectués en automne, en 1998 et en 1999. Le piégeage des smolts (jeunes saumons descendant vers la mer) a été effectué dans la rivière Mossom Creek au cours des printemps de 1999 et de 2000.

Des recensements ont été réalisés dans les principaux cours d'eau qui se jettent dans le bras Port Moody (les rivières Mossom Creek, Noons Creek, Sutterbrook Creek, Schoolhouse North Creek et South Creek) au cours des saisons de frai automnal de 1998 et de 1999. Les saumons kétas (*Oncorhynchus keta*) représentaient l'espèce dominante dans tous les cours d'eau. Des saumons cohos (*O. kisutch*) et deux saumons quinnats (*O. tshawytscha*) ont également été observés. L'échappée totale pour les saumons kétas dans la rivière Mossom Creek a été estimée à 1803 poissons en 1998 et à 658 poissons en 1999. Un petit nombre de saumons kétas ont aussi été dénombrés dans d'autres cours d'eau sous surveillance. Un nombre relativement faible de saumons cohos adultes ont été observés dans les rivières Mossom Creek, Noons Creek, Schoolhouse North Creek et Sutterbrook Creek.

Les premiers saumons kétas adultes ont été remarqués dans la rivière Mossom Creek le 5 octobre en 1998 et le 6 octobre en 1999. Le dernier poisson a été observé au début du mois de décembre pour les deux années. Le maximum du flux migratoire s'étendait entre le 16 octobre et le 9 novembre. On a estimé que la majorité des saumons kétas passaient par le bras Port Moody au cours de la période s'étendant de la deuxième moitié du mois de septembre au début du mois d'octobre.

La température de l'eau à 5 m de fond a été mesurée au cours des mois de septembre et d'octobre 1998 dans le bras Port Moody pour déterminer si le régime thermique du bras convenait aux saumons adultes. Le maximum de la température enregistrée en septembre fut de 16.6 °C, moindre en octobre. La gamme de températures préférée par le saumon kéta adulte lorsqu'il migre en eau douce se situe entre 8.3 °C et 15.6 °C. La présente étude a donc permis de conclure que les déversements d'eaux de refroidissement par la centrale thermique Burrard ne pouvaient avoir d'effets néfastes sur la migration du saumon.

Un piège a été mis en place sur la rivière Mossom Creek au cours des printemps de 1999 et de 2000 pour dénombrer les smolts au cours de leur descente. Un total de 13252 saumons kétas ont été capturés et remis à l'eau en 1999, plus de 18000 en 2000. Au cours de ces deux années, la descente des smolts a commencé début mars et était pratiquement terminée début mai. Un total de 331 smolts ont été capturés en 1999, 875 en 2000. La majorité de ces poissons furent capturés en mars et en avril. Un petit nombre de saumoneaux cohos et de truites fardées ainsi que diverses espèces de chabots ont également été capturés dans le piège. Nous en avons conclu que les jeunes saumons kétas sont probablement présents dans le bras Port Moody entre mars et juillet.

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INTRODUCTION

British Columbia Hydro and Power Authority (BC Hydro) operates the natural gas-fired Burrard Generating Station (BGS), located on Port Moody Arm at the eastern end of Burrard Inlet (Figure 1). Under Permit No. PE-07178, BC Hydro is authorized to discharge up to 1.7 million cubic meters of cooling water per day at temperatures up to 27 °C (BCMELP 1995). An amendment to the Permit in December, 1995, required BC Hydro to prepare and submit an environmental study plan designed to assess the potential effects of the cooling water discharge on water quality and biological communities in Port Moody Arm.

The environmental study plan (BC Hydro 1996) was accepted by BCMELP and the Burrard Inlet Environmental Review Committee. The study plan, which encompassed two years of research investigations, had several components designed to further an understanding of the effects of the BGS cooling water discharge on fish and other aquatic life in Port Moody Arm. One of the issues addressed in the 1997 studies was fish distribution in Port Moody Arm and potential effects of the heated-water discharge on the migration of adult salmonids (Quamme et al. 1997). This assessment concluded that the effect of cooling water from the BGS on migrating salmonids would be dependent upon the species migrating through Port Moody Arm and the season. A two year growth study was also conducted to determine the effect of cooling water on the growth and health of juvenile chum salmon (Greenbank et al. 1998, 2001). The results of this study were also dependent upon the time of year and the seasonal fluctuations in ambient aquatic conditions.

Migration timing was considered to be a critical issue because of the potential of the BGS heated-water discharge to delay or otherwise impact migrating salmon. There is a relationship between the amount of BGS power generation, heat input from solar radiation and ambient seawater temperatures, which influences the overall temperature regime of Port Moody Arm (Taylor et al. 2001). There is also a seasonal shift in ambient seawater temperature at the beginning and end of the summer that creates warmer or cooler overall temperatures in the arm regardless of plant operation. Accordingly, the timing of juvenile and adult salmon migration through Port Moody Arm, relative to the seasonal shift in water temperatures will determine the water temperatures these fish are exposed to. Adult salmon returning to spawn late in the summer would be subjected to higher water temperatures compared to fish returning in the fall. The species that migrate through the area and utilize the local streams for spawning has been documented by Quamme et al. (1997) but there was no site-specific information on when these fish were migrating, and there was little information on the numbers of adults in specific streams.

Ten main tributaries discharge into Port Moody Arm east of the BGS and little information is available on the presence and abundance of fish species in these tributaries. However, many of these tributaries are known to support resident populations of fish as well as juvenile and adult salmon. Several of the tributaries support relatively large numbers of juvenile salmonids as a result of being stocked annually by the Mossom Creek and Noons Creek Hatcheries (Port Moody, BC).

In order to reach their natal stream, migrating adults must pass through Port Moody Arm and

are potentially exposed to cooling waters from the BGS. Juvenile salmon also utilize the estuarine habitat in PMA and may also experience exposure to this effluent. The purpose of this study was to gather quantitative data on species, numbers, and timing of juvenile and adult migrating salmonids and to become more involved with the local stream stewardship groups operating in the area. The information gathered in this study was used to identify a time frame when adult salmon and juvenile chum salmon are most likely to be present in Port Moody Arm, as well as to provide baseline information for the volunteer groups and ecological societies operating in the area.

METHODS

TRIBUTARIES STUDIED IN PORT MOODY ARM

Enumeration efforts were concentrated on the five major creeks that are known to support salmonids and that are also stocked annually with juvenile coho (*Oncorhynchus kisutch*) and chum salmon (*Oncorhynchus keta*). In 1998, we examined Mossom, Noons, Schoolhouse South and Sutterbrook Creeks. In 1999, Schoolhouse North Creek was also monitored. It was assumed that by monitoring the fish in these creeks a large proportion of the numbers of adult salmon returning to spawn in Port Moody Arm tributaries would be documented.

Mossom Creek

Mossom Creek is located on the north shore of Port Moody Arm and is known to support a variety of resident and anadromous fish species. The average wetted width of the lower three reaches is approximately 4.5 m [British Columbia Institute of Technology (BCIT) 1994, 1996]. The first three reaches of the creek were examined up to a series of impassable barriers located in the third reach, approximately 650 m upstream of the Ioco Road culvert.

Mossom Creek is stocked annually with chum and coho salmon fry as well as coho smolts from the Mossom Creek Hatchery. Table 1 details the number of each species and life stage released, as well as the broodstock source of all fish released.

Noons Creek

Noons Creek discharges into the northeast corner of Port Moody Arm. The average channel width and wetted width of the lower three reaches of Noons Creek are 9.0 m and 4.6 m respectively. Stream gradient is 2% in the first reach and 10% and 13% in the second and third reaches respectively. The Noons Creek Hatchery, located near the downstream end of the creek, rears chum and coho salmon. Table 2 details the number of each species and life stage released since 1992, as well as the release location. The majority of the Noons Creek Hatchery salmon are released in Noons Creek, however, some fish are also released in Schoolhouse South Creek (Table 2).

Sutterbrook Creek

Sutterbrook Creek is located on the northeast corner of Port Moody Arm and is distinguished by three sections which are linked by culverts. The distance between the discharge point in Port Moody Arm to the walkway in the local marine park is approximately 185 m. This area has some large pools up to 0.5 m deep that provide holding areas for spawning salmon, and possibly rearing habitat for juvenile coho. Upstream of the Murray Street culvert the creek runs approximately 400 m before the stream divides east along the CPR line and, south under the Barnet Highway. Within this 400 m portion of the creek there is some good salmon spawning and rearing habitat.

Schoolhouse South Creek

The area around the lower reaches of Schoolhouse South Creek is highly developed and the channel is confined with concrete walls in many section. The creek runs through the Pacific Coast Terminals development as well as through the property of Reichhold Chemicals. There is a fish ladder installed at the Barnet Highway culvert which can be a barrier to upstream migration when filled with debris. Upstream of Barnet Highway there is approximately 2 km of usable salmon spawning and rearing habitat. Chum and coho fry are released into this system annually by the Burrard Inlet Marine Enhancement Society (BIMES).

Schoolhouse North Creek

Schoolhouse North Creek is a small tributary which discharges into Port Moody Arm just west of Mossom Creek. There are two culverts located at the bottom of the system which provide passage under a railway and Ioco Road. Upstream of Ioco Road this system branches off into several smaller streams which provide good salmonid rearing and spawning habitat. Both chum salmon and coho salmon are known to spawn in this system and it is likely utilized by anadromous cutthroat trout as well.

Adult salmon surveys

All of the creeks were surveyed in an upstream direction from their mouth. The survey continued until a barrier to fish passage was reached or until no fish were observed for approximately 200 m. All live adult salmon were identified to species, enumerated and their general location noted. Live fish were neither handled nor disturbed. In 1998, efforts were also made to enumerate dead (spawned out) adult salmon. These dead fish were marked by removing the caudal fin rays. The marked fish were left in the creek to decompose naturally. In 1998, Mossom and Noons Creeks were surveyed three times per week while Sutterbrook and Schoolhouse South Creek were surveyed twice weekly. All five creeks were surveyed twice weekly in 1999. While conducting these surveys, care was taken to avoid disrupting adult spawners and spawning habitat. Walking along the edge of the creeks on boulders, limited disturbance to spawning adults and avoided damaging redds.

The day-specific counts of live fish are considered to be estimates of total numbers. For

example, the high densities of adult chum salmon observed in Mossom Creek in the 1998 survey made it impossible to accurately count the number of fish. The approach taken was to count fish that were seen; therefore estimates of the total number of fish were likely less than the actual numbers present. However, since chum salmon are resident in the stream for approximately 10 days and coho are potentially resident for much longer, many fish were observed several times before they had spawned and died.

The day-specific counts of returning chum salmon in Mossom Creek were sufficiently high to calculate total escapement while the day-specific counts in the other four creeks were not. For Mossom Creek, an area-under-the-curve escapement estimate program (Irvine et al. 1993) which incorporates both observer efficiency and period of residency into the total escapement estimate was used.

Juvenile salmon trapping in Mossom Creek

To determine seasonal timing of naturally produced chum salmon fry and coho salmon smolt outmigration a downstream migrant trap was deployed at the downstream end of Mossom Creek in the early spring of 1999 and 2000. Mossom Creek was chosen for this investigation because it supported the largest run of chum salmon. The assumption was that the downstream salmonid migration observed in Mossom Creek would include a large proportion of the naturally produced chum salmon that would utilize the waters of Port Moody Arm and the outmigration timing would likely overlap with that in other tributaries to the area.

A fyke-net and live-box were used to trap the wetted width of the creek. To capture the 1998 broodyear, the trap was deployed on March 5, 1999 and operated until May 8, 1999. For the 1999 broodyear, the trap was installed on February 28, 2000 and operated until May 23, 2000. The trap was designed to intercept all fish migrating downstream with a fine-mesh fyke-net which would direct the fish into a 6" ABS pipe at its downstream end and transport them directly to a baffled live-box where they would remain until released. With the exception of a few days each year when the trap function was compromised due to extremely high water flow events, we assumed that the trap was fishing at 100% efficiency. Photographs 1 - 3 depict the downstream trap and also reveal the major components of the system.

The downstream migrant trap was maintained on a daily basis. The maintenance routine was to inspect the fyke-net and enumerate any mortalities caused by impingement and to ensure there were no holes through which fish could be entrained or escape. Depending on the level of creek discharge, debris was removed from the net since the water levels upstream of the net (and head pressure of the system) would increase as the net was clogged with debris. After the integrity of the net was confirmed, the fish were netted from the live-box with a soft-mesh net and placed into a bucket where they were identified to species and enumerated prior to being released in a low-velocity pool located approximately 10 m downstream of the live-box. After completing the daily maintenance, the trap was left unattended until the next morning. During high flow events, the trap was also cleaned prior to nightfall to ensure that the trap fished efficiently throughout the night.

A sub-sample of about 30 juvenile chum salmon would be removed approximately one day per week and measured for fork length prior to being released. These fish were anaesthetized with a dilute solution of tricaine methanesulfonate (TMS) at a concentration of approximately 40 $mg \cdot L^{-1}$. The fish were allowed to recover from the anaesthetic before being released into the creek.

RESULTS

ADULT SALMON ENUMERATION IN MOSSOM CREEK

1998

A total of 5448 live adult chum salmon were counted during the 1998 spawning season in Mossom Creek (Table 3). Based on the area-under-the-curve estimate with an observer efficiency estimated to be 80% and a residency period of 10 days, the total escapement in Mossom Creek was estimated to be 1803 fish (Table 4). However, since there has never been a mark-recapture study completed on this system, the residency period of chum salmon is an estimate based on available literature. Salo (1991) documented post-spawning longevity for females and males combined to range from 11.2 to 15.2 days after they had been placed in a spawning channel. In a separate study conducted on 30 lower Fraser Valley streams, Schubert (1982) documented chum salmon residency to be 10 days. Other estimates of chum salmon residency in BC lower mainland systems are as low as 5 days (A. McLean, Environmental Services, Power Supply, BC Hydro, Burnaby, BC; pers.comm.). Adjusting the estimated residency period influences the total escapement estimate substantially. For example, a 7-day residency increases the estimate to 2575 fish while a 13-day residency period decreases the total escapement estimate to 1387. Since the residency period is uncertain for this system in this year, the total escapement estimate for chum salmon in 1998 would be estimated to be 1800 fish ± 500.

Upstream migration began in early October and the first adult chum salmon was observed on October 5 (Figure 2). The numbers of chum salmon in the creek increased sharply on October 16 (286 live fish, compared with 44 on October 14) and increased consistently from there, peaking on October 26 when 860 were counted. After October 28, the numbers of chum salmon entering the creek decreased and only 12 fish were observed by the end of November (Table 3).

Rainfall data was acquired from an Environment Canada weather station (WSC ID 1710J.) located in Coquitlam, just south of Port Moody Arm. Upstream migration of both chum and coho salmon increased significantly after major rainfall events. The weather in 1998 was anomalous in that in September there was no rainfall until September 17, when 13.7 mm was measured at the weather station. We did not observe chum salmon in the streams until October 5 (Mossom Creek) and coho salmon until October 7 (Noons Creek). The first observation of chum salmon in 1999 was October 6 (Mossom Creek) and the first coho was noted on October 9 (Noons Creek). Tables 3 and 4 contain all pertinent data.

A total of 717 dead (spawned-out) adult chum were counted in Mossom Creek (Table 3). This number represents less than half of the escapement estimate. Many of the spawned-out fish were moved out of the system during high-flow events.

The sum of the day-specific counts of live coho adults in Mossom Creek was 22 (Table 5), while only 6 spawned-out coho salmon were enumerated. Most of the coho were observed on November 18 (Table 5) following a major storm event in early November that greatly increased creek water levels. When the coho were stationary they were difficult to observe, and as a consequence the numbers were likely under-estimated. There was also one dead male chinook salmon (*Oncorhynchus tshawytscha*) located in the lower reach of Mossom Creek on December 4. This was the only chinook observed in any of the Port Moody Arm tributaries that were examined during the 1998 spawning season.

Although this investigation did not intend to assess the suitability of salmonid spawning habitat in these streams, some information was collected, and previous work conducted by the BCIT (1994) was reviewed. Spawning habitat throughout the fish-accessible portion of Mossom Creek was variable. Excellent spawning habitat for chum and coho salmon was found in the lower reaches of the creeks, in which gravel predominated in the substrate. Considering an overall length of approximately 850 m of fish-accessible habitat in Mossom Creek for upstream migrant salmon, and an average wetted width over the lower three reaches of 4.5 m, an estimate of the total area frequented by spawning salmon is 3825 m^2: the area of spawning habitat was estimated to be approximately 10% (~400 m^2). Schroder (1973) determined that the optimum spawning density of chum salmon in controlled flow channels of Big Beef Creek was 0.6 females$\cdot m^{-2}$. At this density Mossom Creek would support approximately 240 females (480 fish), which is approximately 55% of the peak numbers of live chum salmon adults observed in the creek at any one time. It also represents 27% of the "area-under-the-curve" estimate for numbers of chum salmon spawners utilizing Mossom Creek. Other estimates of optimum spawning density (Salo 1991) are as high as 2 to 3 females$\cdot m^{-2}$ which would allow a maximum of 1200 females (2400 fish) to spawn in this creek. Based on our observations, the creek appeared to be overpopulated relative to the availability of suitable spawning habitat, and redd superimposition may have occurred.

1999

The day-specific counts of adult chum salmon in Mossom Creek during the 1999 survey totaled 1253 fish (Table 6). The "area-under-the-curve" escapement estimate was 658 fish based on 80% observer efficiency and a residency period of 10 days (Table 7). This estimate was much lower than the 1998 estimate but this year was more typical of returns for this system. Spawned-out fish were not counted in the 1999 surveys.

The timing of migration of adults into the creek in 1999 was similar to that which occurred in 1998. The first chum salmon was noted on October 6 and 3 chum salmon were observed during the last survey that was completed on December 3. The peak of the migration was on November 11 when 198 chum salmon were observed in the system (Figure 3).

Coho salmon were much more abundant throughout Port Moody Arm in 1999 than in 1998. The total of the day-specific counts of coho salmon was 74 fish (Table 6). An "area-under-the-curve" escapement estimate was not generated for coho salmon because we had no direct information on their residency period in this system, and it is known to be highly variable. For example, the time between peak migration and peak spawning in the Big Qualicum River was 32 days (Fraser et al. 1983). In many other north American streams there has been little correlation between time of entry of an adult salmon into a stream and the spawning date (Sandercock 1991). The first coho salmon was observed on October 14 and there was 1 fish seen on the last survey which was completed on December 3. The peak of migration was on November 3 when 21 coho salmon were observed.

ADULT SALMON ENUMERATION IN NOONS CREEK

1998

During this investigation, the sum of the day-specific counts of live chum salmon adults in Noons Creek was 146. Only 13 dead chum salmon were observed (Table 3). The first returning adults were observed on October 7, with the peak occurring on October 21 when 33 adults were counted. Two live and 36 dead coho adults were enumerated. Two of these coho had a left ventricle fin clip, which revealed that these fish had strayed from their natal Capilano River.

There is a gap in the data collected from Noons Creek from November 13 until December 2. Observations were not made during this period in response to a complaint filed to the Department of Fisheries and Oceans (DFO) by a Port Moody Ecological Society member concerning the research team working in Noons Creek, walking in the stream. Although DFO considered that the complaint was unjustified, BC Hydro's public relations department decided that no further work would be conducted in the stream until the complaint was addressed and resolved.

All of the adult salmon observed in Noons Creek were downstream of the Ioco Road culvert, and the majority of these fish were observed in a large pool directly downstream of this culvert. No adult salmon were observed upstream of the Ioco Road culvert. Depending on the creek discharge, the culvert appeared passable to fish at most times, however, it was a significant barrier to migration upstream. At baseline flows, the water depth in the culvert was 0.1 m. However, at higher flows the pool below the culvert was deeper as was the water within the culvert.

1999

In 1999, a total of 34 chum salmon were counted. The first fish was observed on October 12 and the last 2 chum salmon were observed on November 29. The peak of the chum salmon migration was on November 11 when 20 chum were seen in the system. As in 1998, no chum salmon were observed upstream of the Ioco Road culvert.

The number of coho salmon adults increased significantly in 1999 over that recorded in 1998. There were 122 coho spawners counted in the system with the first being seen on October 9. There were 2 coho observed on the last survey which was conducted on December 13. The peak number of 18 coho was seen on November 26 and 29. There was also 15 coho salmon observed October 12.

ADULT SALMON ENUMERATION IN SUTTERBROOK CREEK

1998

The day-specific counts of live adult chum observed in Sutterbrook Creek totaled 29, while 6 dead (spawned-out) chum were counted (Table 3). The first fish in the creek was observed on October 21, and the peak of 10 live adult chum salmon was noted on November 6. There were no adult coho salmon observed in Sutterbrook Creek during this investigation.

Several adult chum salmon were observed holding in the downstream portion of Sutterbrook Creek (i.e. in the Marine Park), however, no spawning activity was observed in that area. The section of creek between the Marine Park and the Murray Street culvert was difficult to access due to dense riparian overgrowth and was, accordingly, only surveyed twice during this investigation. No adult salmon were observed in this area during the two surveys. There is good salmon spawning habitat in Sutterbrook Creek upstream of the Murray Street culvert. This section of the creek is approximately 400 m long with suitable spawning habitat throughout. Habitat enhancement has occurred on this system in the upstream portion of this 400 m reach. The lower sections of the enhanced habitat were utilized by adult chum salmon in 1998 but no adult salmon were observed in its upper section.

1999

In 1999, the daily counts of chum salmon in Sutterbrook Creek totaled 39. The chum salmon were observed in the system for about 3 weeks beginning November 3 and the last 3 fish being observed on November 26. A peak of 13 chum salmon was observed on November 11. Overall, these counts represented about 20 adults spawning in the system.

Coho salmon were observed in Sutterbrook creek in 1999. One spawning pair was observed twice, on November 11 and 17 and a third coho was observed on November 23.

ADULT SALMON ENUMERATION IN SCHOOLHOUSE SOUTH CREEK

1998

No adult salmonids were observed in Schoolhouse South Creek during the twice-weekly observations. Employees at the Reichold Chemical plant also monitored the creek within their property and they also failed to observe adult fish. There was one barrier to adult salmon migration noted in the area that was surveyed: the Barnet Highway culvert, and a potential barrier (flow dependent) was located approximately 50 m downstream of this culvert.

1999

There were no adult salmon observed in Schoolhouse South creek in the 1999 spawning season.

ADULT SALMON ENUMERATION IN SCHOOLHOUSE NORTH CREEK

The adult salmon survey in 1999 was the first to have occurred on Schoolhouse North Creek. There were 20 chum salmon in the system between October 27 and November 17. This survey was limited because access was difficult upstream of the Ioco Road culvert. Four adult coho salmon were observed in the vicinity of the creek's fish ladder between November 11 and 26.

JUVENILE SALMON TRAPPING IN MOSSOM CREEK

1999

The first chum salmon fry was captured on March 10 1999, 5 days after the trap was installed. A total of 13,252 chum salmon fry were captured, the last one being on May 7 1999. Figure 4 illustrates the temporal distribution of the catch and shows a slightly bimodal distribution with two peak-catch days of 914 and 1033 chum salmon fry on April 8 and April 20 respectively. Total mortality of chum fry observed both on the nets and in the trap was 79 fish (0.60% of the catch).

The estimate of the total number of adults in Mossom Creek was approximately 1800 fish. Based on a reported male:female sex ratio of 1.22:1, the number of females was estimated to be 810. The number of these females was then multiplied by an estimate of 2500 eggs per female. Banford and Baily (1979) found the average fecundity of chum salmon in 11 streams in British Columbia was 2,765. However, it has been suggested that races in small, short streams tend to be less fecund (Salo 1991). Our estimate of 810 females and 2500 eggs per female would result in the deposition of about two million eggs. Factors such as spawning density as well as others which include stream discharge, substrate composition, water temperature and dissolved oxygen levels may influence egg to fry survival. From our observations of spawning chum salmon in Mossom Creek we consider that the spawning density was high and that spawning habitat was definitely limiting in the 1998 spawning season. The 13,000 chum salmon fry captured in the downstream migrant live-box represented 0.64% of the predicted egg deposition from the Mossom Creek spawning population.

Coho fry were first captured in the trap on April 10, 1999; 3 were counted (Figure 5). A total of 331 coho fry were observed with a peak of 83 occurring on April 20, 1999. The last coho fry was captured on May 5, 1999. There was a total of 6 coho smolts and 5 cutthroat trout parr captured throughout the study period. The coho smolts ranged in length from 79 to 107 mm while the cutthroat trout ranged in length from 120 to 159 mm. Sixteen sculpins were captured throughout the study which ranged in length from 25 to 120 mm. All catch data are shown in Table 8.

2000

A total of 36,734 chum salmon fry were collected and released from the downstream migrant trap in Mossom Creek in 2000. Approximately 18,000 of these fish were released from Mossom Creek Hatchery, thus approximately 18,734 were produced within the creek. The first chum fry was captured on March 1 and the last 16 fry were captured on May 3 (Figure 6). This timing of out-migration was similar to that recorded in the previous year. Chum mortality in the fry trap was 0.29%.

Our estimate of the total adult chum salmon escapement for the 1999 broodyear was 658. Using the same sex ratio of 1.22:1 (male:female), our estimate of adult females was 296. Based on the estimated fecundity of 2500 eggs per adult female, a potential egg deposition estimate of 0.74 million was predicted. The 18,734 wild fry of the 36,734 captured in the trap would, therefore, represent an egg to fry survival of 2.5%. Although the estimated egg to fry survival was higher for the 1999 broodyear, the survival rates are still very low compared with the 6% to 31% range reported for chum salmon in other coastal streams (Cowan 1991; Scrivener 1988).

There was a total of 875 coho fry captured. The first was captured on March 1 and the last on May 21. Figure 7 illustrates the temporal distribution of the coho fry catch which shows a peak out-migration around the first week of April. The largest daily catch of coho fry was 56 on April 7. All catch data are shown in Table 9.

There was a total of 125 coho smolts captured in the Mossom Creek downstream migrant trap in 2000. The majority of the smolts were captured in the first week of May (Figure 8) just after the chum fry outmigration had decreased. The fork-length of the coho smolts ranged from 75 to 110 mm (Figure 9).

DISCUSSION

This investigation has provided a database of fish usage for tributaries entering Port Moody Arm. It is expected that these data will be augmented in future years, and thereby assist in assessing the success of the hatcheries in the area.

The enumeration of adult salmon commenced in September 1998 and late August 1999 and were completed in December of each year after there were very few or no adult salmon present in the creeks. Confining the program to the fall period has some limitations as other species may spawn at different times of the year. Healy (1991) stated that there are three distinct chinook salmon runs in the Fraser River: an early run peaking in July, a late run peaking in September/October, and a third, smaller, run in August. It is, therefore, conceivable that chinook salmon may spawn in Port Moody Arm tributaries at times other than in the fall. We observed one dead chinook salmon in Mossom Creek on December 4 1998 and one dead chinook in Noons Creek on October 29 1999. Previous to these observations there had been no documentation of this species spawning in any of the other Port Moody Arm tributaries.

Anadromous cutthroat trout are known to inhabit Port Moody Arm and are likely present in many of its tributaries. This species was also identified by Quamme et al. (1997) as a potential concern in regard to the effects of the operation of the BGS. Cutthroat trout may spawn more than once and adults will often enter freshwater streams during the fall to feed on the eggs of other salmonids (Salo 1991). Cutthroat trout generally spawn in December through May and their young may spend from 1 to 4 or more years in freshwater prior to entering seawater in the spring. From knowledge of their life history pattern, it was speculated that cutthroat trout may be present in Port Moody Arm not only during the summer months but also at other times of the year. Fish, possibly cutthroat trout, were occasionally observed in several of the creeks monitored, however, it was not possible to definitively identify the individuals.

TIMING OF ADULT SALMON MIGRATION IN PORT MOODY ARM

The first chum salmon were noted on October 5 and 6 in Mossom Creek in 1998 and 1999 respectively. These first fish also represented the first chum salmon in any of the tributaries monitored. In both years, the chum salmon migration period in Mossom Creek covered the chum salmon migration period for all of the creeks that were monitored.

No direct information was collected on the presence of adult chum salmon in Port Moody Arm. However, considering when upstream migration started and the documented behavior of chum salmon prior to moving into freshwater, estimates were made of the times when these fish may be moving through Port Moody Arm. Salo (1991) stated that migrating adult chum salmon generally only spend a few days milling at the mouth of a stream before ascending. A study conducted by Eames et al. (1981) reported that some fish remained in Skagit Bay (State of Washington, USA) for 21 days after being tagged and before they moved upstream. If the chum salmon in Port Moody Arm remained in the estuary for this length of time prior to moving upstream, the first few fish would have moved through the arm in mid-September and large numbers would have started moving through later that month. No salmon were observed holding in the estuary at the mouth of the creeks, and it is therefore uncertain how long these fish resided in Port Moody Arm prior to entering the creeks.

In 1998, coho salmon were first observed in Mossom Creek on October 19 and in Noons Creek on November 9. In 1999, this species was observed first in Noons Creek on October 9 and then in Mossom Creek on October 14. In 1999, there were also reports of coho salmon in Noons Creek in September. These dates are consistent with those documented by Fraser et al. (1983), who found that the normal period for coho salmon to begin their migration in BC is September and October. Coho salmon may stay near the mouth of the stream for weeks until stream discharge and temperature are suitable for upstream migration. There is considerable variation in migration rates and seasonal timing of the upstream migration of this species which makes it difficult to determine when these fish may have moved through Port Moody Arm. However, individuals are likely present in Port Moody Arm through September and some may be present in late August. Ricker (1972) stated that coho salmon rarely exhibit seasonal runs to single tributaries. When seasonal runs do appear, they are generally in response to particular flow conditions. Since a fall run of coho was observed in Mossom and Noons Creeks, it is improbable

that an earlier (summer) run of coho occurs in Port Moody Arm.

IMPLICATIONS OF BURRARD GENERATING STATION OPERATION ON TIMING OF FALL MIGRATIONS OF ADULT SALMON

Interactions between the BGS cooling water discharge into Port Moody Arm and its potential to affect migrating adult salmon moving through this region in September and October have been examined. In September of 1998 the BGS was operating four electricity generating units for the entire month. The mean daily temperatures of the cooling water discharge (measured continuously at the outlet) ranged from 24.8° C to 26.3 °C. In October of 1998, the station was operating three units continuously and one unit 90% of the time. The mean daily cooling water discharge temperatures ranged from 23.5° C to 26.2 °C. The maximum discharge temperatures for these two months were approaching the permitted level of ≤ 27.0 °C (BCMELP 1995).

Throughout the course of this investigation, water temperatures in the vicinity of the BGS and throughout Port Moody Arm were collected. Water temperatures were continuously logged at 30-min intervals at depths ranging from 1.0 m to 12.0 m. Only the 1998 temperature data set has been included in the following analysis. As part of the analysis completed by Taylor et al. (2001), water temperature contours generated from 1998 temperature data were illustrated on maps of Port Moody Arm. The water temperature values used for the contours are based on data collected at a 5-m depth. In September 1998, temperature contours at a 5-m depth ranged from 15.0 °C at Gosse Point to 17.6 °C at the east end of the arm on the mudflats in September (Figure 10). The temperatures in the vicinity of the BGS and Mossom Creek ranged from 16.0 °C to 16.6 °C. In October 1998, the temperatures at a 5-m depth were considerably lower and ranged from 12.0 °C at Gosse Point to 13.0 °C at the east end mudflats (Figure 11). Brett (1951) documented the preferred temperature for juvenile chum salmon as 14.1 °C in fresh water and Birtwell et al. (2001a) determined that the preferred temperature range was 13.7 °C - 17.9 °C in seawater. The preferred "migration water temperature" range for adult chum salmon in fresh water has been stated to be between 8.3 °C and 15.6 °C (Bjorn and Reiser 1991) and no information was found for seawater. The temperature range for Port Moody Arm at a 5-m depth, during months that adult chum salmon migrated through these waters, in 1998 and 1999, bracketed the preferred temperature for juvenile chum salmon and encompassed that for migrating adults. The temperature did not approach the lethal level of 23.8 °C for juveniles (Brett 1952), nor did it attain the 50% avoidance threshold of 20.2 °C (Birtwell et al. 2001a).

In 1999, the electrical power generation was lower, and there were two generating units operating continuously through September and two units operating approximately 50% of the time in October. The resulting temperature of the cooling water discharge was lower compared to the 1998 values. The average cooling water discharge temperature was 20.5 °C in September and 15.7 °C in October. The maximum discharge temperature was 24.5 °C and 22.1 °C for September and October respectively. Water temperature contours were not generated for this period in 1999. However, the heat input from BGS was lower in 1999 compared to 1998 and the assessment of temperature effects on migrating salmon would likely be unchanged for 1999. That is, the overall temperature regime in Port Moody Arm in the 1999 spawning season would probably be very similar to, or lower than, that observed in 1998. Considering the timing of

migration of adult chum and coho salmon observed during this investigation, and the temperature ranges within Port Moody Arm during this period, it is unlikely that any significant negative interactions between the BGS operation and the adult salmon migration occurred during the 1998 and 1999 spawning seasons.

JUVENILE CHUM SALMON DOWNSTREAM MIGRATION IN MOSSOM CREEK

The juvenile chum salmon started to move out of Mossom Creek in early March and continued through early May for both 1998 and 1999 broodyears. This record compares well with other systems in the area (Cope 1998, 1999). Salo (1991) stated that migration occurs from February through May in southern BC. The juvenile chum salmon will likely reside inshore (in Port Moody Arm) until there is a decline in prey resources and also when they have grown large enough to pursue larger prey items and avoid near shore predators. Juvenile chum salmon in Port Moody Arm probably start to move offshore in May and are likely not present by the end of July. Hwang et al. (1994) sampled chum salmon fry with seine nets at two locations in Port Moody Arm. The first chum fry were captured on March 10 and there were two peak-catch days of 280 fry on April 22 and 28; no chum fry were captured after June 16 in 1994. Juvenile chum salmon have been recorded as early as January in the estuary of the Fraser River (Birtwell, I.K., Fisheries and Oceans, Canada, West Vancouver, BC, unpublished data), but the majority of chum salmon typically enter estuarine waters in March (Healy 1982; Macdonald and Chang 1993), and peak in April and May thereafter decreasing as they slowly (3 to 5 $km \cdot d^{-1}$) migrate to the Pacific Ocean (Simenstad and Salo 1987). However, some researchers have recorded their presence in Georgia Strait in the fall (Healey 1982). Thus it may be expected that this salmonid species will utilize Port Moody Arm for a period of about 5 months and that within this period, individuals may be resident there for days to weeks (Levy et al. 1979). However, this study did not attempt to determine whether juvenile chum salmon utilize warm waters within the BGS discharge plume. Rather, we collected site-specific data on the timing of outmigration of naturally produced salmon in the area. Juvenile chum salmon may have moved offshore before seasonally elevated water temperatures in Port Moody Arm reach levels that may be harmful to them with prolonged residency. However, during the chum salmon near-shore residency period, water temperatures may reach harmful levels within the initial mixing zone of the BGS discharge and over the mudflats at the east end of the arm. This topic has been discussed more thoroughly in related reports considering the growth and health of juvenile chum salmon exposed to BGS cooling water (Greenbank et al. 2001) and their behavior and susceptibility to predation (Birtwell et al. 2001a, Birtwell et al. 2001b).

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Table 1. Mossom Creek Hatchery salmonid release history

Chum Salmon Release History

Year	Life Stage	Number released	Broodstock source
1988	fry	35,000	-
1989	fry	1,000	-
1992	fry	5,500	Mossom
1993	fry	10,000	-
1994	fry	19,500	Mossom
1995	fry	58,577	Mossom
1996	fry	58,577	-
1997	fry	26,000	Mossom
1998	fry	42,124	Indian
1998	fry	28,467	Indian

- Data unavailable

Coho salmon release history

Year	Life Stage	Number released	Broodstock source
1990	fry	53,000	Mossom
1991	fry	10,400	Mossom
1993	fry	7,750	Mossom
1993	smolt	547	Mossom
1994	fry	8,022	Mossom
1994	smolt	2,272	Mossom
1995	fry	2,500	Mossom
1995	smolt	5,754	Capilano
1995	smolt	1,500	Mossom
1996	smolt	4,201	Noons
1998	fry	548	-
1998	smolt	1,181	Capilano
1998	smolt	34	Capilano
1998	smolt	573	Capilano
1998	smolt	1,149	Capilano
1998	smolt	432	Capilano
1998	smolt	572	Capilano
1998	smolt	100	Capilano
1998	smolt	23	Capilano
1998	smolt	100	Capilano
1998	fry	548	Seymour
1998	fry	18	Seymour

- Data unavailable

Table 2. Noons Creek Hatchery salmonid release history

Chum Salmon Release History

Year	Life Stage	Number released	Release Location
1993	Fry	34,297	Noons Creek
1994	Fry	41,722	Noons Creek
1995	Fry	47,625	Noons Creek
1996	Fry	30,000	Noons Creek
1996	Fry	30,000	Schoolhouse South
1997	Fry	35,000	Noons Creek
1997	Fry	35,000	Schoolhouse South

Coho salmon release history

Year	Life Stage	Number released	Release Location
1992	smolt	11,000	Noons Creek
1993	smolt	15,000	Noons Creek
1994	smolt	14,000	Noons Creek
1995	smolt	10,000	Noons Creek
1996	smolt	17,600	Noons Creek
1997	smolt	20,500	Noons Creek

Table 3. Day-specific counts of adult chum salmon, 1998

	Mossom Creek		Noons Creek		Sutterbrook Creek	
Date	**Live**	**Dead**	**Live**	**Dead**	**Live**	**Dead**
11-Sep						
14-Sep						
18-Sep						
21-Sep						
25-Sep						
28-Sep						
2-Oct						
5-Oct	1					
7-Oct	8		2			
9-Oct	10		1	1		
11-Oct		4				
12-Oct	25					
14-Oct	44					
16-Oct	286		5			
18-Oct		5				
19-Oct	430	5				
2-Oct		8				
21-Oct	645	8	33		1	
23-Oct	726	14	31	2		1
25-Oct		19				
26-Oct	860	68	17	2		
28-Oct	760	70	10		2	
30-Oct	685	158	17	1	2	
2-Nov	454	190	13	2		
6-Nov	223	82	12	1	10	1
7-Nov		16				
9-Nov	180	46	5	2		
13-Nov			-	-	1	
18-Nov	50	13	-	-	4	
20-Nov			-	-	3	
23-Nov	8	2	-	-	3	
25-Nov	10	3	-	-	2	
27-Nov	18	2	-	-		
30-Nov	12		-	-	1	
2-Dec	8	2	-	-		1
4-Dec	4	1		2		3
7-Dec	1	1				
Totals	5448	717	146	13	29	6

- No data collection during this period.

Table 4. Area-under-the-curve estimate of total escapement for adult chum salmon generated for Mossom Creek, 1998.

AREA-UNDER-CURVE (AUC) SALMON ESCAPEMENT ESTIMATOR

STREAM: Mossom Creek

YEAR: 1998

SPECIES: Chum Salmon

Enter Stream Residence Time in Days?	10	
Enter First Julian Day when fish arrive?	279	(optional)
Enter Last Julian Day when fish are alive?	342	(optional)
Enter estimated observer efficiency (%)?	80	
Enter the Total Stream Length (m)?	850	
Enter the Number of Sample Sites?	1	
Enter the Total Length (m) of all Sample Sites	850	

Notes

Mossom Creek Spawner Survey Data, Fall 1998

Jeff Greenbank and Sherri Rendek

Escapement Estimate

AUC =	18028
ESCAPE. =	1803

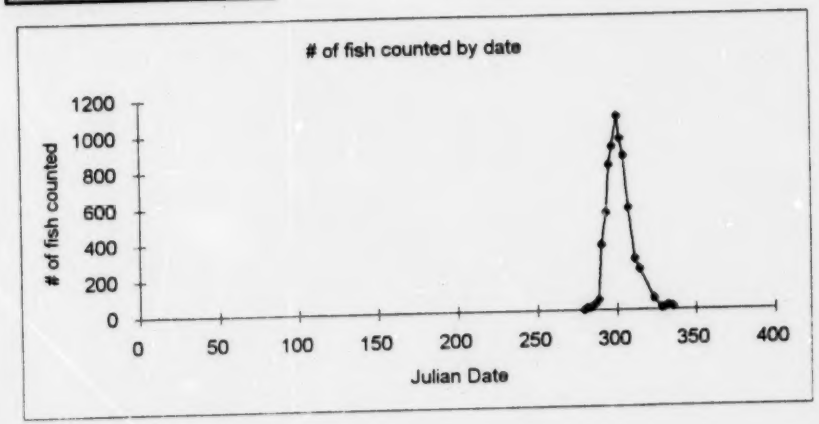


Table 5. Day-specific counts of adult coho salmon, 1998.

	Mossom Creek		Noons Creek	
Date	**Live**	**Dead**	**Live**	**Dead**
16-Oct	0	0		
19-Oct	1			
23-Oct	1			
2-Nov	1			
9-Nov		1	2	1
16-Nov			-	2
17-Nov			-	3
18-Nov	11	1	-	
19-Nov			-	9
21-Nov			-	3
23-Nov	2		-	
27-Nov		2	-	
30-Nov	2		-	7
2-Dec	3	0	-	
4-Dec	1	2	0	5
5-Dec				2
7-Dec	0	0	0	0
10-Dec				2
12-Dec				2
Totals	22	6	2	36

- No data collection during this period.

Table 6. Day-specific counts of adult salmon in Mossom Creek, 1999.

Date	Chum	Coho
27-Aug		
31-Aug		
2-Sep		
6-Sep		
9-Sep		
14-Sep		
22-Sep		
27-Sep		
30-Sep		
6-Oct	3	
8-Oct	21	
12-Oct	35	
14-Oct	69	1
18-Oct	67	1
20-Oct	79	
25-Oct	99	
27-Oct	116	
29-Oct	165	1
3-Nov	151	21
11-Nov	198	11
17-Nov	115	13
19-Nov	81	12
23-Nov	28	8
26-Nov	13	2
29-Nov	10	3
3-Dec	3	1
Totals	**1253**	**74**

Table 7. Area-under-the-curve estimate of total escapement for adult chum salmon generated for Mossom Creek, 1999.

AREA-UNDER-CURVE (AUC) SALMON ESCAPEMENT ESTIMATOR

STREAM: Mossom Creek

YEAR: 1999

SPECIES: Chum Salmon

Enter Stream Residence Time in Days?	**10**	
Enter First Julian Day when fish arrive?	**279**	(optional)
Enter Last Julian Day when fish are alive?	**340**	(optional)
Enter estimated observer efficiency (%)?	**80**	
Enter the Total Stream Length (m)?	**850**	
Enter the Number of Sample Sites?	**1**	
Enter the Total Length (m) of all Sample Sites	**850**	

Notes

Mossom Creek Spawner Survey Data, Fall 1999

Jeff Greenbank

Escapement Estimate

AUC =	**6581**
ESCAPE. =	**658**

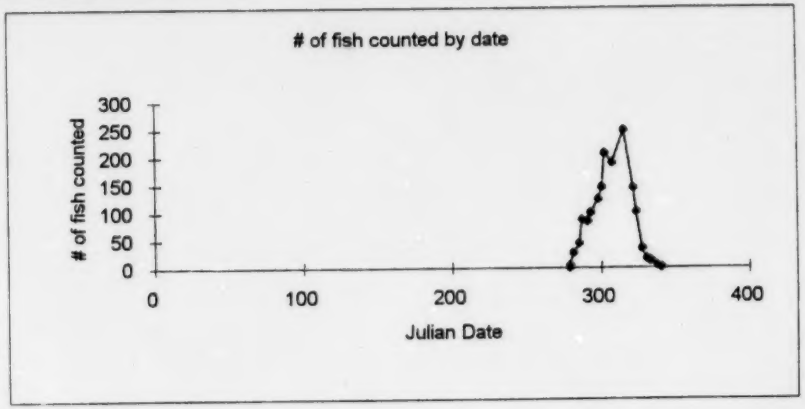


Table 8. Downstream migrant trap data, Mossom Creek (spring 1999)

Date	W. Temp.	Chum Fry	Coho Fry	Coho Parr (mm)	Cutthroat (mm)	Sculpin Spp.(mm)	Dead chum
6-Mar	4.0	0					
7-Mar	4.0	0					
8-Mar	4.0	0		1(80)		4	1
9-Mar	4.0	0					
10-Mar	4.5	1					
11-Mar	4.5	4		1(90)	1(300)	1(60)	
12-Mar		5				1(120)	1
13-Mar		65					6
14-Mar		7					2
15-Mar		0				1(55)	
16-Mar		7					4
17-Mar		3					
18-Mar		18					3
19-Mar		25		1(95)		1(60)	
20-Mar		46					
21-Mar		98				3	
22-Mar		49					1
23-Mar		295					2
24-Mar		213					
25-Mar		217					4
26-Mar		195					
27-Mar		167					
28-Mar		186					
29-Mar	5.5	382					
30-Mar	5.5	309					
31-Mar	4.5	387					2
1-Apr	4.0	347					6
2-Apr	4.5	321					2
3-Apr	5.0	577					4
4-Apr	6.0	526					1
5-Apr	5.0	624		1(79)			
6-Apr	5.0	141					
7-Apr	5.0	113					2
8-Apr	4.0	914					11
9-Apr	4.0	238					4
10-Apr	6.0	65	3				9
11-Apr	5.5	267					1
12-Apr	7.0	118	2			1(93)	1
13-Apr	5.0	370	2				8
14-Apr	4.0	116	5				
15-Apr	5.0	126	3				
16-Apr	6.0	133	7				
17-Apr	7.0	434	9			1(25)	

Table 8 (cont.) Downstream migrant trap data, Mossom Creek (spring 1999)

Date	W. Temp.	Chum Fry	Coho Fry	Coho Parr (mm)	Cutthroat (mm)	Sculpin Spp.(mm)	Dead chum
18-Apr	8.5	361	8				
19-Apr	6.0	318	4				
20-Apr	6.0	1033	83			2(50,90)	4
21-Apr	6.0	245	37		1(150)	1(90)	
22-Apr	7.0	342	35				
23-Apr	7.0	368	29				
24-Apr	7.5	298	30				
25-Apr	8.5	391	25				
26-Apr	8.5	585	12				
27-Apr	8.5	475	6				
28-Apr	8.0	151	5				
29-Apr	8.0	109	3				
30-Apr	7.0	40	2				
1-May	6.5	60	4				
2-May	6.5	38	2				
3-May	6.0	150	6				
4-May	6.5	142	8				
5-May	6.5	22	1	2 (107,102)			
6-May	6.5	12	0				
7-May	6.5	3	0				
8-May	6.5	0	0				
Totals	5.9	13252	331	6	2	12	79 (0.60%)

Table 9. Downstream migrant trap data, Mossom Creek (spring 2000)

Date	W. Temp.	Chum Fry	Coho Fry	Coho Smolt (mm)	Cutthroat (mm)	Sculpin Spp.(mm)	Dead chum
29-Feb	5.0						
1-Mar	5.0	1	1	5		3	
2-Mar	5.0						
3-Mar	5.0	11					2
4-Mar	5.0	4					
5-Mar	5.0						
6-Mar	5.0						
7-Mar	5.0						
8-Mar	5.0	9	2	5		2 (30, 60)	
9-Mar	5.0	2				1 (25)	
10-Mar	5.0	14	2				
11-Mar	5.0	27	2			3 (30 -80)	
12-Mar	5.0	10	2				
13-Mar	5.0	5				1	
14-Mar	5.0	35	6				10
15-Mar	5.0	80	3	3			3
16-Mar	5.0	75	1	1		3	
17-Mar	5.0	82	4			3	
18-Mar	5.0	35	4				
19-Mar	5.0	6	1				
20-Mar	5.0	155					
21-Mar	5.0	170	2	2		6	10
22-Mar	5.0	795	12	2			8
23-Mar	5.0	1,572	11		1 (90)		16
24-Mar	5.0	453	16	4			
25-Mar	5.0	335	7	2			4
26-Mar	5.0	289	8				
27-Mar	5.0	240	6			5	
28-Mar	6.0	488	14			3	6
29-Mar	4.5	818	31			2 (110, 118)	4
30-Mar	7.0	344	15			4	1
31-Mar	6.0	572	40			3	2
1-Apr	7.0	350	16				
2-Apr	9.0 (pm)	277	10			3	2
3-Apr	7.5	788	50				
4-Apr	7.5	906	54				
5-Apr		386	19				
6-Apr	7.5	574	33				
7-Apr	7.0	811	56				3
8-Apr	8.0	758	40				1
9-Apr	8.0	514	32				2
10-Apr	8.0	568	28				1
11-Apr	9.0	1,658	29			13 - small	3
12-Apr	9.0	1,990	20				1
13-Apr	9.0	1,540	17				2
14-Apr	8.5	816	9				

Table 9 (cont.) Downstream migrant trap data, Mossom Creek (spring 2000)

Date	W. Temp.	Chum Fry	Coho Fry	Coho Smolt (mm)	Cutthroat (mm)	Sculpin Spp.(mm)	Dead chum
15-Apr	8.0	2,254	7			3	4
16-Apr	7.5	3,500	28				2
17-Apr	7.0	2,714	20				3
18-Apr	8.0	1,280	31		1 (80)		2
19-Apr	8.5	1,109	27				3
20-Apr	9.0	544	15			18	2
21-Apr	8.5	1,623	37				2
22-Apr	8.5	1,287	30			4	3
23-Apr	7.5	1,556	13	2		7	2
24-Apr	8.0	550	12				
25-Apr	8.0	483	8	1			
26-Apr	7.5	353	7	1			
27-Apr	7.5	268	9	6			
28-Apr	7.0						
29-Apr	6.5	312	7	18			4
30-Apr	7.5	157	12	14			
1-May	7.5	134	9	16			
2-May	7.5	47	5	14	1 (110)		
3-May	7.0	16	4	12			
4-May	7.0	0	4	7			
5-May	Panels Out						
6-May	Panels Out						
7-May	Panels Out						
8-May	Panels In		2				
9-May	5.0		8	3			
10-May	5.5		12	3	1(112)		
11-May	Panels Out						
12-May	Panels Out						
13-May	Panels Out						
14-May	Panels Out						
15-May	Panels Out						
16-May	Panels In					21	
17-May	7.5	0	5	3			
18-May	7.5	0	1	3			
19-May	8.0	0	6	1		42	
20-May	7.5	0	2	0		35	
21-May	7.5	0	4	2	1 (160)	45	
22-May	Panels Out						
23-May	Trap Removed						
Totals	6.6	36,734	927	125			106

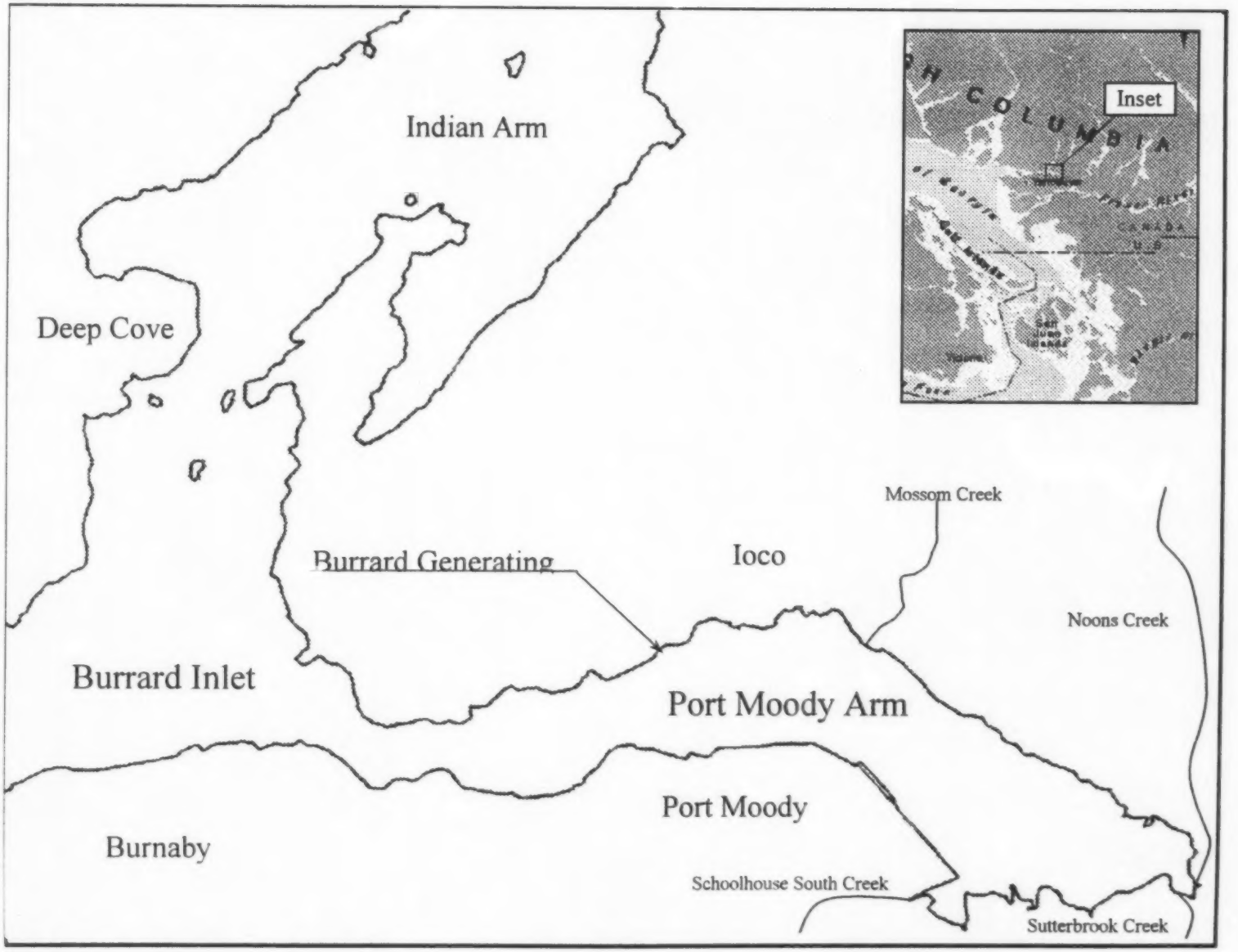


Figure 1. Location of BGS and tributaries surveyed on Port Moody Arm, British Columbia.

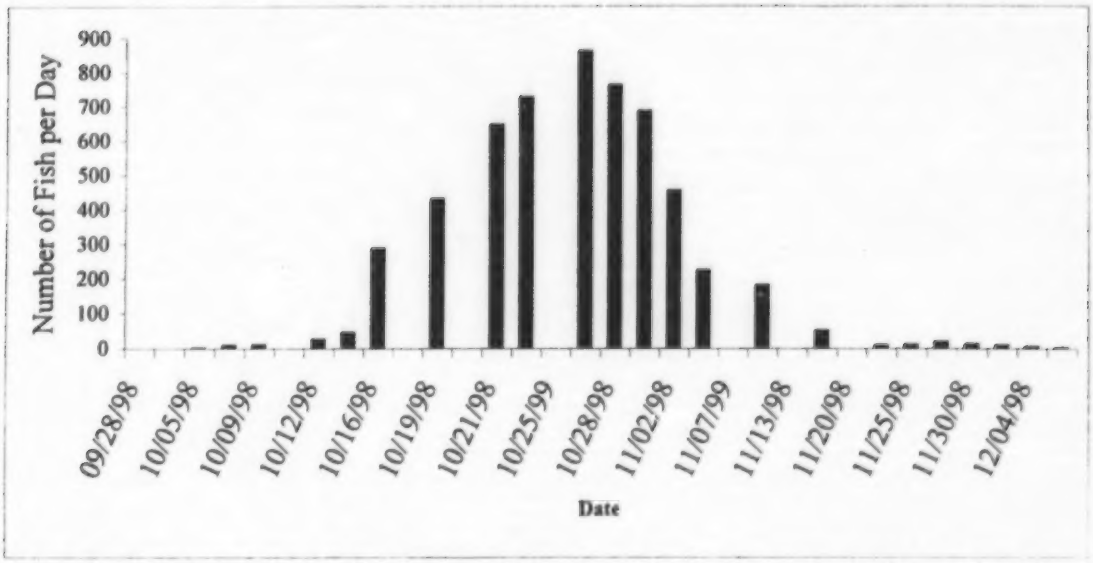


Figure 2. Number of live spawning chum salmon counted per day in Mossom Creek, fall 1998. (Total AUC Estimate = 1803)

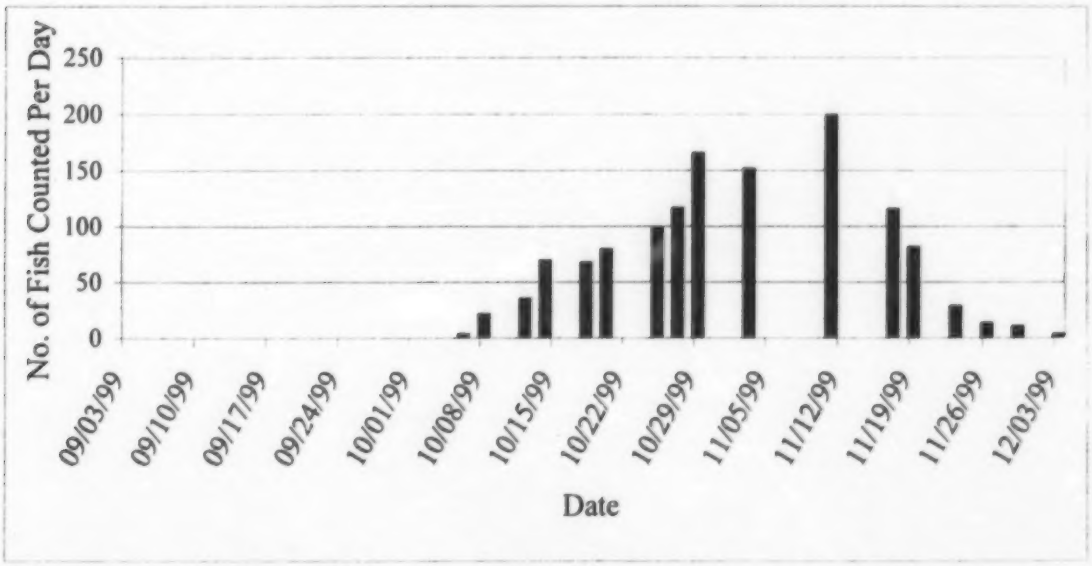


Figure 3. Number of live spawning chum salmon counted per day in Mossom Creek, fall 1999. (Total AUC Estimate = 658)

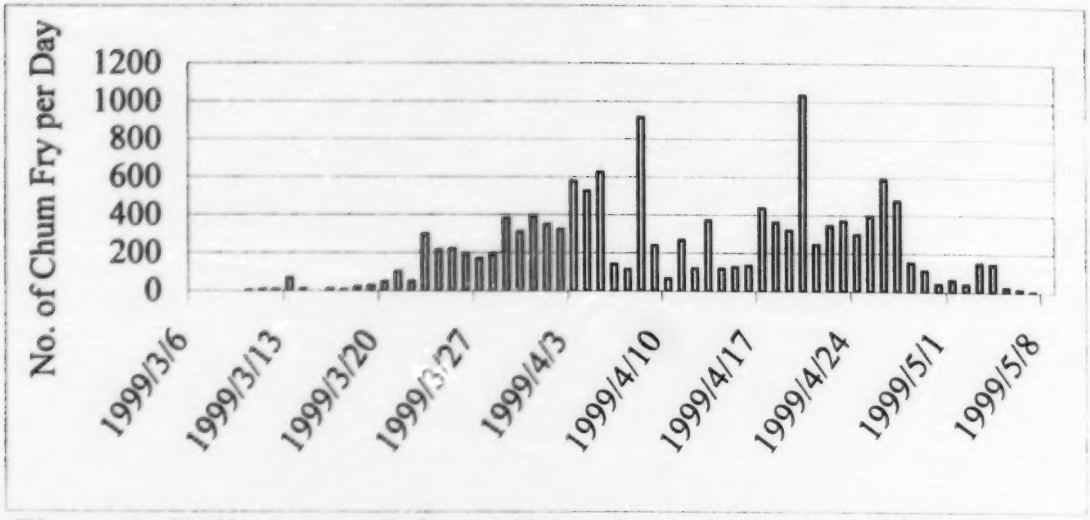


Figure 4. Daily count of chum salmon fry outmigration, Mossom Creek, 1999 (13,252 Total).

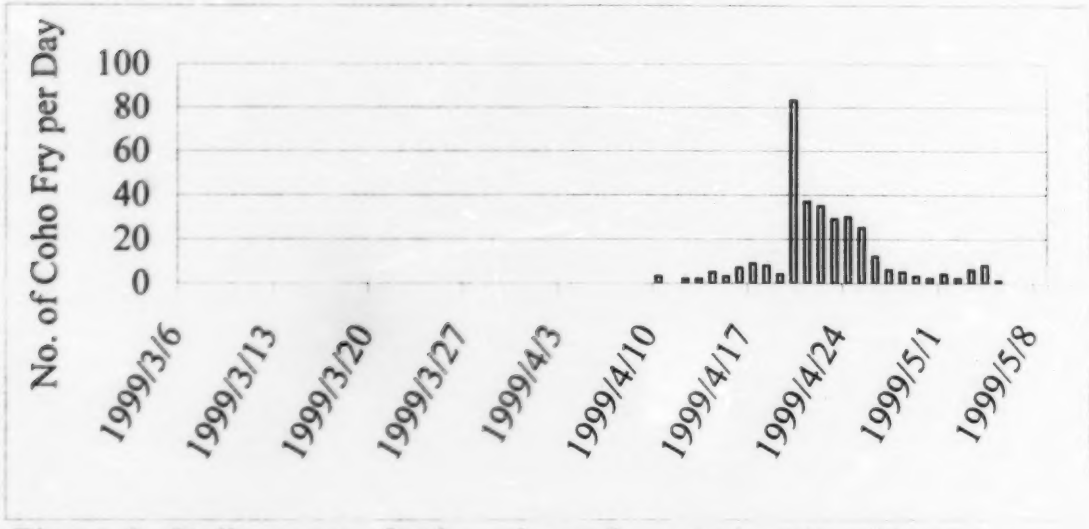


Figure 5. Daily count of coho salmon fry outmigration, Mossom Creek, 1999 (331 Total).

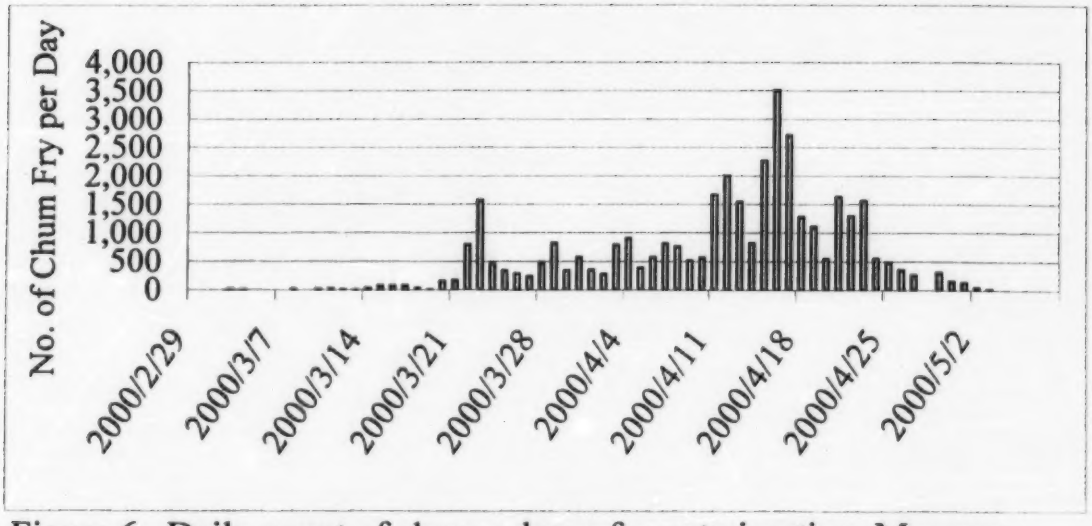


Figure 6. Daily count of chum salmon fry outmigration, Mossom Creek, 2000 (Total fry 18,734).

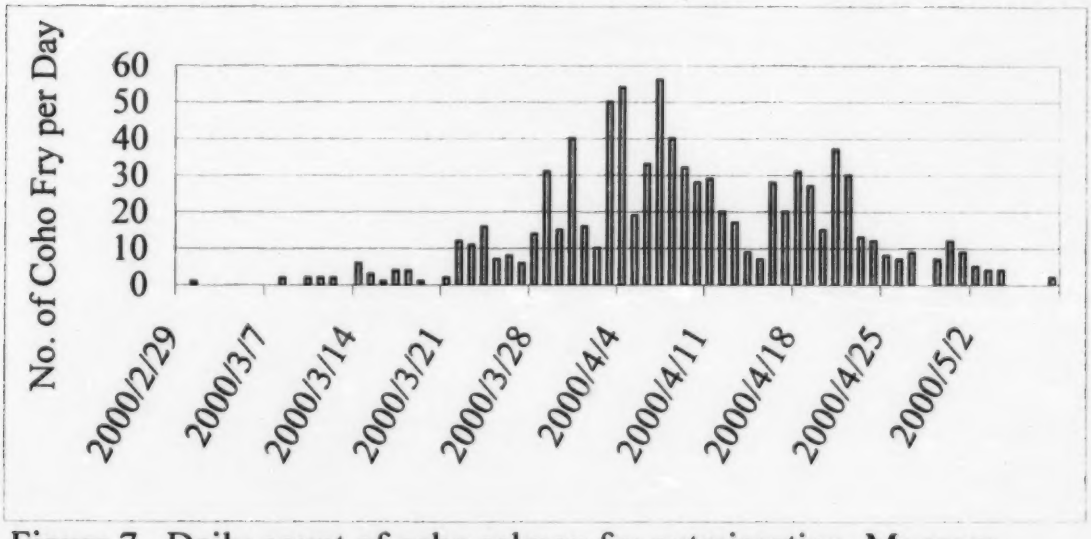


Figure 7. Daily count of coho salmon fry outmigration, Mossom Creek, 2000 (Total fry 875).

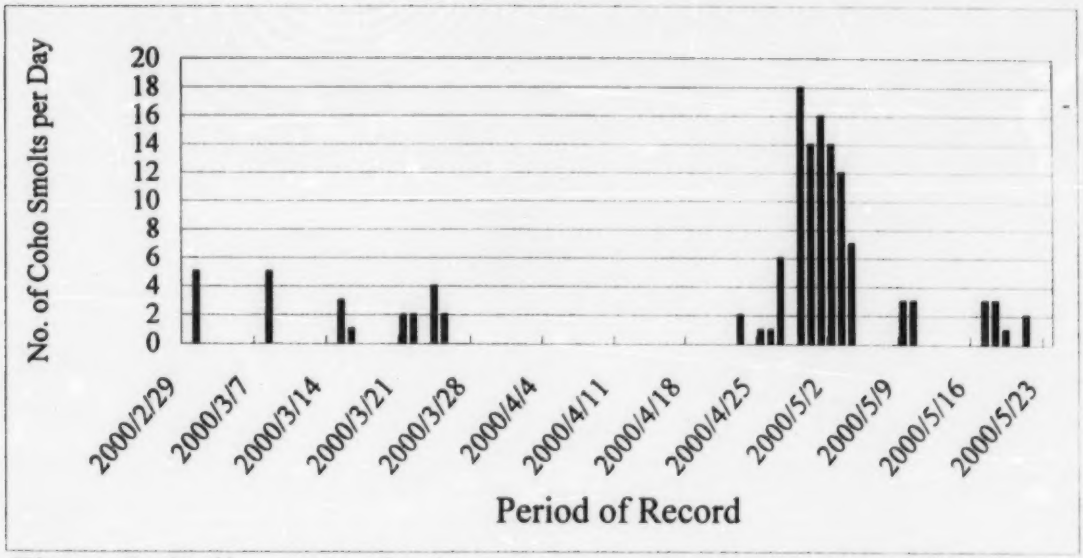


Figure 8. Daily count of coho salmon smolt outmigration, Mossom Creek, spring 2000 (Total smolt 125).

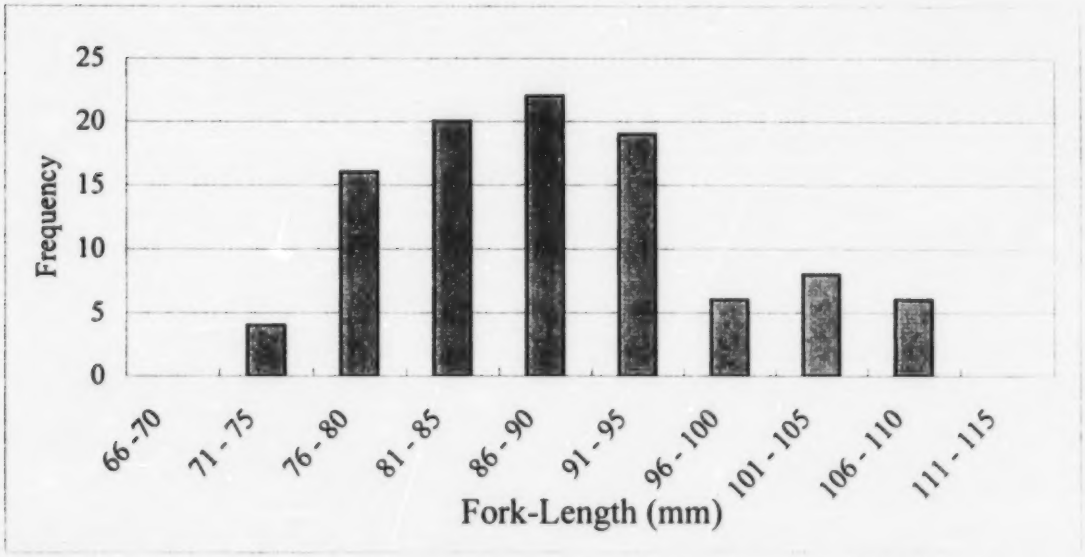


Figure 9. Length-frequency histogram illustrating the fork-length distribution of coho smolts captured at Mossom Creek, spring 2000 (n = 101).

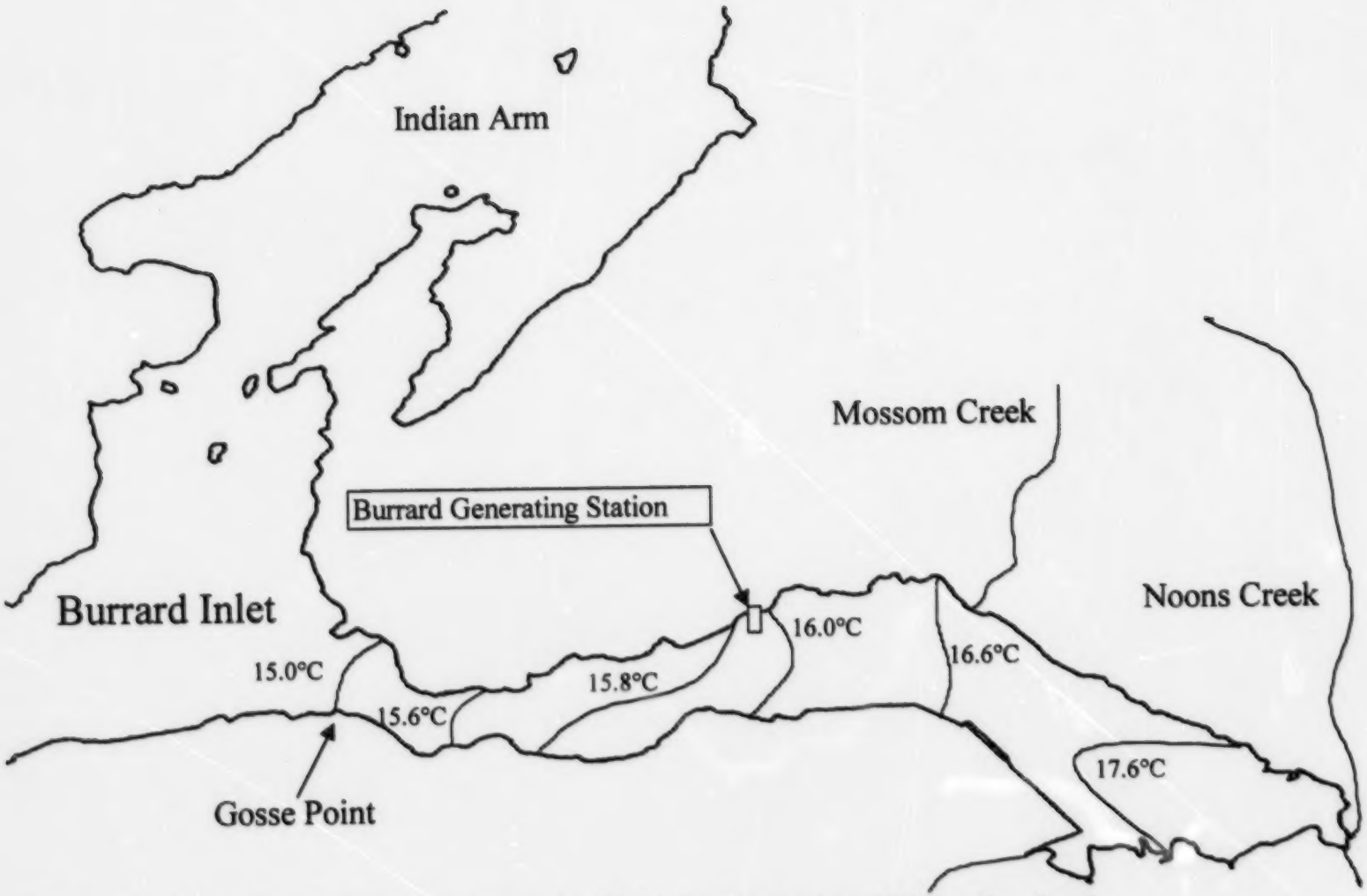


Figure 10. Mean temperature contours for PMA in September 1998 at 5m depth.

Contour Lines Generated From ASL Environmental Sciences Inc., Sidney, BC; 1999.

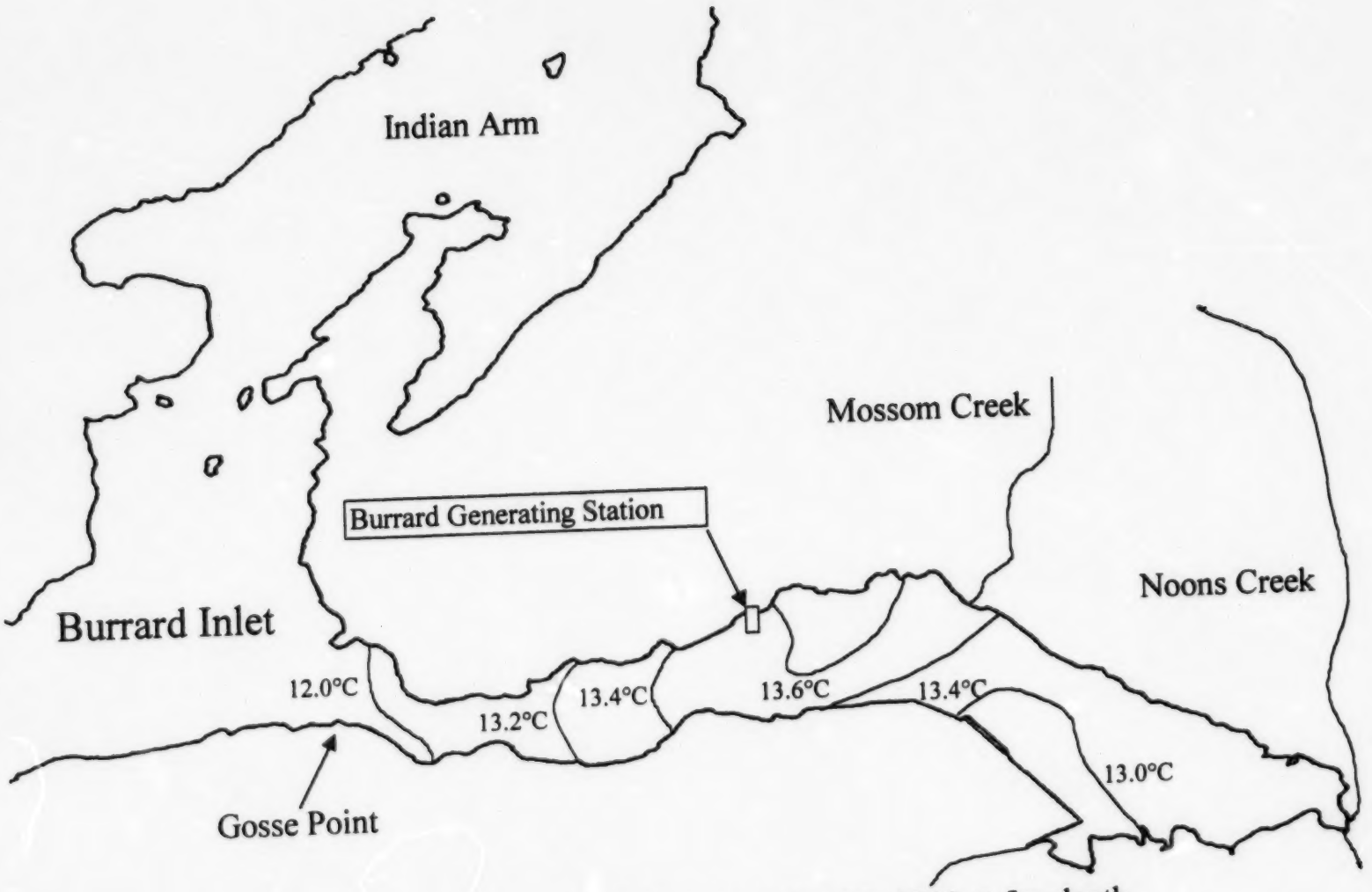
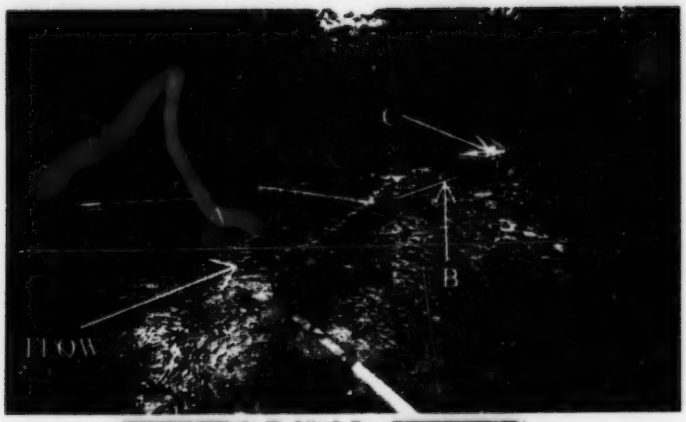


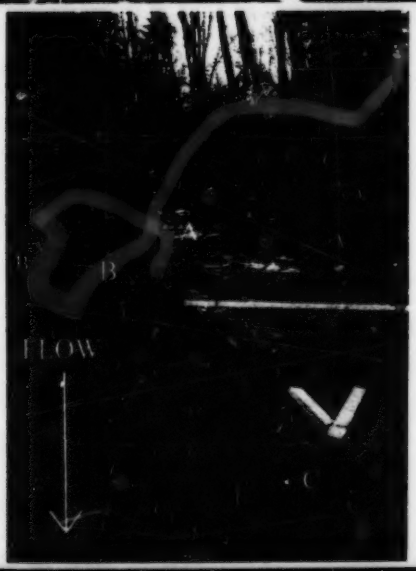
Figure 11. Mean temperature contours for PMA on October 29, 1998 at 5m depth.

Contour Lines Generated From ASL Environmental Sciences Inc., Sidney, BC; 1999.



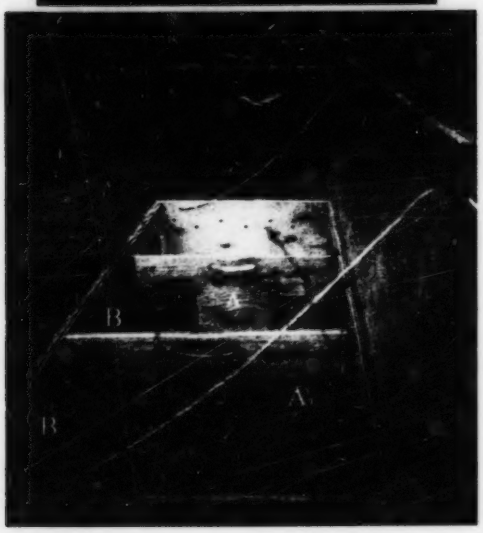
Photograph 1. Downstream view of migrant trap from right bank.

A. Fyke net wing wall.
B. Inlet pipe to live-box. Constructed of 6" ABS pipe
C. Live box.



Photograph 2. Upstream view of fyke net from live box.

A. Chain-link debris fence located upstream of fyke net.
B. Fyke net wing wall.
C. Inlet pie to live-box



Photograph 3. Upstream view of live-box, inlet pipe and fyke net.
Live-box Dimensions:
2m long x 0.6m wide x 0.6m deep

A. Live-box baffles with alternating water passage holes to reduce flow in downstream end of live-box
B. Screened openings (fiberglass mesh) to allow water flow through live-box. Three opening per side, one in back wall.